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UNCINARIASIS IN TEXAS.[1]

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(From the Pathological Laboratory of the University of Texas, 1903, No. 6.)

Introductory. Some years since the writer, interested in consequence of having frequently met with various human parasites in the work of the Pathological Laboratory of the University of Texas, elicited from the venerable Ferdinand Herff, of San Antonio, in the course of a conversation concerning his experience with parasitic worms, a number of interesting data upon the subject, and later had the pleasure of inducing Dr. Herff to publish these experiences. In one of his articles,[2] Dr. Herff refers to his having met certain small round worms in the intestine of a Mexican woman who had died in his care, which, at the time of the autopsy, he had regarded as young ascarides, and had neglected in consequence, but which at the time of writing he was disposed to believe, as he recalled the specimens, to have been examples of *uncinaria duodenalis*. In 1895 (by mistake stated 1893 in the article of Dr. M. C. Schaefer in *Medical News*, October 26, 1901, and quoted thence by Stiles and others), while demonstrating in class the microscopic features of fecal matter (obtained from the common closet of the college and supposed to be normal), the writer encountered ova which at first, from ignorance of the subject, he supposed to be those of *oxyuris vermicularis*, but which after further study at the time were determined as those of *uncinaria duodenalis*. Although what at the time was believed a reasonable effort was made to discover the host of the worms, the search was not successful. A number of times during the following years in the intestines of experiment dogs the writer came upon examples of the allied species *uncinaria canina*, and was inclined to believe that the prevalence of the latter could be regarded as suggesting fit conditions in the same locality for prevalence of the human species. Moreover, in several instances he had found peculiar small ecchymotic wounds in the upper part of the small intestine of human beings at autopsy, similar to those found in dogs which have been infested by hookworms, from which again the suspicion of human uncinariasis arose; and, although the worms were not found in these particular instances, this failure may easily be understood when it is stated that in the routine autopsy work the unopened intestines were formerly always handed over to a laboratory servant, to be opened and washed before examination was made of the interior appearances, under which circumstances it is quite likely that any parasites present were unnoticed and washed away. Finally, in 1901, in a case in the United States Marine Hospital Wards in St. Mary's Infirmary under the care of Acting Surgeon William Keiller, Dr. M. Charlotte Schaefer, while examining the stools for *amœba coli*, encountered certain bodies which she brought to the writer for identification. They were recognized as the ova of the hookworm, and after Dr. Keiller, with this knowledge in his possession, had administered a suitable dose of thymol, followed by salts, there were obtained from the discharges a few more than one hundred examples of the worm. This case[1] has been reported by Dr. Schaefer.[2] Within a day or two after this discovery (the ova from this case having in the meantime been demonstrated to the medical class) the class was working over some presumably normal human fecal matter taken from the common closet of the school, when several of the students called the attention of the demonstrator in charge, Dr. William Gammon, to the existence of the same ova in this specimen, and on investigation they were found in large numbers in a large proportion of the class preparations. After this discovery the writer posted upon the college bulletin board an announcement of the fact and its importance, indicating the particular apartment of the closet and the approximate time of the deposit of the feces therein, and asking that any of the students recalling the use of this apartment at about the stated time should communicate with him. Several persons thus applied, and microscopic examination of their passages was made, but without discovery of any of the ova. These occurrences took place in the latter part of February, 1901. In the latter part of the following month it happened that with this positive knowledge of the existence of the parasite in the intestines of at least one or more of the students the writer noted a distinct eosinophilia in the blood of two students who, among others, applied at this time for examination for the parasite of malaria, and was led thereby to suggest examination of the stools for the possible discovery of these parasites as a complication in each case. In the feces from each of these cases (Cases I. and II.) the ova of the hookworm were found, and in the blood of the first the malarial organism was also afterward encountered by the writer; but, unfortunately, the latter gentleman almost immediately left school without notice to the writer, and the discovery of the ova was not followed by the removal of the parasites themselves. The second was, however, presently given thymol, and the worms obtained in the stools passed thereafter.

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[1] Read in Section of Medicine, American Medical Association, New Orleans, 1903.
[2] Trans. Texas State Medical Association, 1894; Texas Medical Journal, June, 1894.

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[1] The parasites from this case are in possession of the writer and have been identified as examples of *uncinaria americana*. It is of interest to add that in this case not only were the above-mentioned ova met with, but also a number of eggs of the whipworm and numerous *amœbæ coli*. Subsequently one male *trichocephalus dispar* was obtained from the stools, but no more at any time. At autopsy some months later a small, shrivelled hydatid cyst was found in the liver, and in the lungs and pericardium advanced tuberculosis.

[2] Trans. Texas State Medical Association, 1901; Medical News, October 26, 1901.

These two instances of the discovery of the hookworm in persons living practically all their lives in Texas, and hence having acquired the parasite from conditions prevailing in the State, together with the other data above mentioned, caused the writer to undertake the examination of the stools of as many of the students in the school as could be induced to submit specimens to him. It was thought that the group of medical students coming from many portions of the State would serve in an unusual degree as an index of the population of the State, and the discovery of the parasites in persons whose homes were widely distributed would establish in an unquestionable manner the prevalence of the worm as a native entozoon of this general district of the country. In the search thus undertaken the writer was materially aided by the following gentlemen, then members of the Junior Medical Class, whom he wishes here to thank for their assistance: J. J. Terrill, W. A. Allison, J. R. Elliott, D. H. Lawrence, O. H. Plant, C. D. Cantrell, and M. R. Sharp. With the co-operation of these gentlemen the writer was able, between May 7 and June 12, 1901 (the latter date being the time of finishing the final class examinations in the school and the time when the undergraduates, as a rule, left Galveston), to examine with a fair degree of care eighty-six examples of feces submitted by as many individuals (inclusive of a few previously examined by the writer).

In this group of eighty-six individuals eight persons were found to be infested with hookworms; and doubtless had it been possible to have extended the search throughout the entire student body, as at first planned, in the remaining one hundred and fifty or more, other instances would have been discovered.[1] It has been a matter of regret to the writer that he has been unable, because of imperative school duties, to supplement this original series by other investigations in the same systematic and a more thorough manner.

In addition to these, it is not improper to add at this date that several other cases have been recognized in the wards of the hospitals of Galveston by some of the colleagues of the writer, which will doubtless be published in the future, and that one case has been reported to the writer by Dr. J. S. Wooten, from Austin, Texas, and two cases by Dr. W. D. Jones, from Marshall. To date, as far as the writer is aware, these cases comprise those which have thus far been recognized from the State of Texas (from which the uncertain but probable case of Herff and the proved case of Dr. Schaefer should be excluded as being both of Mexican origin); but in the light of numerous discoveries of the parasite elsewhere in the United States, particularly following the brilliant investigations conducted by Dr. Charles Wardell Stiles,[2] zoölogist of the United States Public Health and Marine Hospital Service in the Carolinas and Georgia, these findings indicate the probability of a wide and important prevalence of this zoöparasite in Texas, and also in the general district of the South Atlantic and Gulf States.

DETAILS OF THE WRITER'S CASES. The distribution of seven of the eight cases mentioned in the present series is indicated by the linear-shaded counties in the accompanying map of Texas (Fig. 1), the stippled counties representing the home counties of those students examined but not found infected. The eighth infested individual prior to his life in Galveston as a medical student has had no permanent residence for years; was originally from the western part of Louisiana, but had been employed in various occupations at various times in Texas, Louisiana, Indian Territory, Arkansas, New Mexico, Mexico, and Colorado. For this reason his home is not indicated in the map. In all the counties indicated as the homes of persons found to be infested the observation of Stiles (*sup. cit.*) that the disease is especially prevalent in sandy districts is well borne out. Red River County (77) is in the greatest portion sandy, with red clay subsoil, and its water

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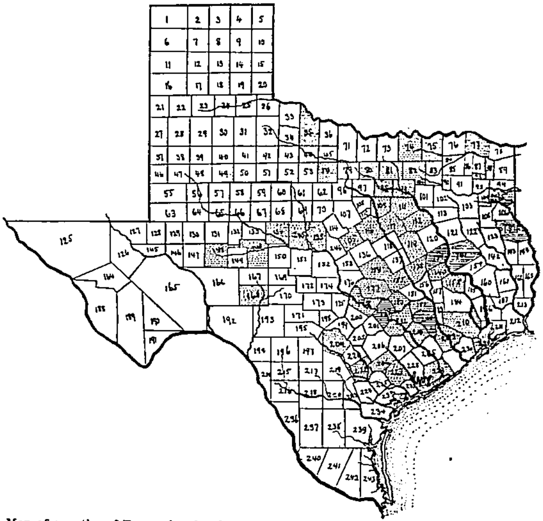
[1] It may be noted as a matter of further interest that in addition to the cases of uncinaria there were encountered in this series one case of *trichocephalus dispar*, one of *tænia mediocanellata*, eighteen of *amœba coli*, and eight of trichomonads and other infusoria.

[2] Bulletin 10, Hygienic Laboratory, United States Public Health and Marine Hospital Service, Washington, D. C.

FIG. 1.



Map of counties of Texas, showing by stipple shading the homes of persons examined for uncinaria ova but not showing same; showing homes of those infected by *uncinaria americana* by linear shading. Counties mentioned according to following list;

1, Dallam; 2, Sherman; 3, Hansford; 4, Ochiltree; 5, Lipscomb; 6, Hartley; 7, Moore; 8, Hutchinson; 9, Parnell; 10, Hemphill; 11, Oldham; 12, Potter; 13, Carson; 14, Gray; 15, Wheeler; 16, Deaf Smith; 17, Randall; 18, Armstrong; 19, Donley; 20, Collingsworth; 21, Parmer; 22, Castro; 23, Swisher; 24, Briscoe; 25, Hall; 26, Childress; 27, Bailey; 28, Lamb; 29, Hale; 30, Floyd; 31, Motley; 32, Cottle; 33, Hardeman; 34, Foard; 35, *Wilbarger;* 36, Wichita; 37, Cochran; 38, Hockley; 39, Lubbeck; 40, Crosby; 41, Dickens; 42, King; 43, Knox; 44, Baylor; 45, Archer; 46, Yoakum; 47, Terry; 48, Lynn; 49, Garza; 50, Kent; 51, Stonewall; 52, Haskell; 53, Throckmorton; 54, *Young;* 55, Gaines; 56, Dawson; 57, Borden; 58, Scurry; 59, Fisher; 60, Jones; 61, Shackelford; 62, Stephens; 63, Andrews; 64, Martin; 65, Howard; 66, Mitchell; 67, Nolan; 68, Taylor; 69, Callahan; 70, Eastland; 71, Clay; 72, Montague; 73, Cooke; 74, *Grayson;* 75, *Fannin;* 76, Lamar; 77, RED RIVER; 78, Bowie; 79, Jack; 80, *Wise;* 81, *Denton;* 82, *Collin;* 83, Hunt; 84, Delta; 85, Hopkins; 86, Franklin; 87, Titus; 88, Morris; 89, Cass; 90, Rains; 91, Wood; 92, Camp; 93, Upshur; 94, Marion; 95, HARRISON; 96, Palo Pinto; 97, Parker; 98, *Tarrant;* 99, *Dallas;* 100, *Rockwall;* 101, Kaufman; 102, Van Zandt; 103, Smith; 104, Gregg; 105, Rusk; 106, Panola; 107, Erath; 108, Hood; 109, *Johnson;* 110, *Somervell;* 111, *Ellis;* 112, *Navarro;* 113, Henderson; 114, Comanche; 115, *Hamilton;* 116, *Bosque;* 117, *Hill;* 118, McLennan; 119, *Limestone;* 120, Freestone; 121, Anderson; 122, Cherokee, 123, Nacogdoches; 124, SHELBY; 125, El Paso; 126, Reeves; 127, Loving; 128, Winkler; 129, Ector; 130, Midland; 131, Glasscock; 132, Sterling; 133, Coke; 134, *Runnels;* 135, *Brown;* 136, Coryell; 137, Falls; 138, *Robertson;* 139, LEON; 140, *Madison;* 141, HOUSTON; 142, Angelina; 143, San Augustine; 144 Sabine; 145, Ward; 146, Crane; 147, Upton; 148, *Tom Green;* 149, Irion; 150, Concho; 151, McCulloch; 152, San Saba; 153, Lampasas; 154, *Bell;* 155, *Milam;* 156, Brazos; 157, Grimes; 158, *Walker;* 159, Trinity; 160, Polk; 161, Tyler; 162, Jasper; 163, Newton; 164, Jeff Davis; 165, Pecos; 166, Crockett; 167, Schleicher; 168, *Sutton;* 169, Menard; 170, Kimble; 171, Kerr; 172, Mason; 173, Gillespie; 174, Llano; 175, Blanco; 176, Burnett; 177, *Williamson;* 178, Travis; 179, BASTROP; 180, *Lee;* 181, Burleson; 182, *Washington;* 183, Waller; 184, Montgomery; 185, San Jacinto; 186, Liberty; 187, Hardin; 188, Presidio; 189, Brewster, 190, Buchel; 191, Foley; 192, Valverde; 193, Edwards; 194, Kinney; 195, Bandera; 196, Uvalde; 197, Medina; 198, Kendall; 199, Comal; 200, Hays; 201, Caldwell; 202, *Fayette;* 203, *Colorado;* 204, *Bexar;* 205, Guadalupe; 206, Gonzales; 207, Lavaca; 208, Wharton; 209, *Fort Bend;* 210, *Harris;* 211, Chambers; 212, Jefferson; 213, Orange; 214, Maverick; 215, Zavalla; 216, Dimmitt; 217, Frio; 218, La Salle; 219, Atascosa; 220, McMullen; 221, Wilson; 222, *Karnes;* 223, Live Oak; 224, Bee; 225, Goliad; 226, *Dewitt;* 227, *Victoria;* 228, Jackson; 229, *Matagorda;* 230, Brazoria; 231, *Galveston;* 232, Relugio; 233, Calhoun; 234, San Patricio; 235, *Aransas;* 236, Webb; 237, Encinal; 238, Duval; 239, Nueces; 240, Zapata; 241, Starr; 242, Hidalgo; 243, Cameron; 244, AUSTIN; 245, *Coleman;* 246, Mills.

supply is largely from surface wells; Leon (139), Bastrop (179), Harrison (95), and Shelby (124) counties may be similarly described (the last named has a small section of black river bottom land); the extreme east and west of Houston County (141) is black river bottom, the centre sandy, with red clay subsoil; the western and southern portions of Austin County (244) are black, approaching the "black waxy" type, its Brazos River bottom land is a red loam, its centre is sandy. All these districts depend mainly on surface wells for their water supply.

The eight cases included in the present series may be outlined as follows:

CASE I.—H., male, aged twenty-two years, medical student; has resided in Shelby County (124) all his life, save that for a year he worked on the H., E. and W. Railway between Houston, Texas, and Logansport, La., and after November 15, 1900, was in Galveston in attendance upon his medical course. At his home the water supply was invariably from surface wells; during his railway service it was from various sources; surface wells, springs, and creeks; since his residence in Galveston from deep artesian wells and from overground cisterns. There is no history of dirt-eating or other similar practises, and none of ground-itch. Within five years prior to the discovery of the hookworm ova in his discharges he had had no severe disease of any type beyond a number of malarial attacks, which invariably responded promptly to quinine. For about a year, however, he had noted more or less disturbance of an indefinite type in the abdomen, some irregularity of the bowel action, and slight discomfort in the upper portion of the abdomen. The patient first consulted the writer in the latter part of March, 1901, because of a malaria-like paroxysm the evening before. He was a sparely-built man, of medium height, anæmic in appearance, with a somewhat drawn, anxious expression, poor circulatory tone, no evidence of pulmonary disorder, no appreciated urinary fault, but complaining of moderate abdominal discomfort in addition to the history of the supposed malarial paroxysm. Examination of the blood at first failed to show the presence of hæmatozoa, the examination being made ten or twelve hours after the chill and the patient having had no quinine in the meantime. A distinct eosinophilia was, however, apparent, but no numerical determination of the red and white cells and no differential count of the leucocytes were made. The presence of the excess of eosinophile cells in association with the patient's appearance and with the failure to find the malarial organism in his blood led the writer to suspect that this man might be the individual from whom had been passed the hookworm ova found in the closet a few weeks previously, and a request for fecal matter was made. The following day, in a mushy, light-brown stool, the ova in question were quickly found in moderate numbers;[1] and a second blood examination made the same day resulted in finding a few ordinary tertian malarial parasites. Quinine in large doses was administered, and the patient was urged to submit to medication with thymol, with a view of ridding him of the worms. This he declined, and the malarial paroxysms persisting in spite of the quinine, he shortly, without notifying the writer, left Galveston, and has never returned. Letters from him, however, state that after some time he recovered from the malarial attacks, but that his health continues to be far from good, the abdominal disturbances being persistent.

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[1] None of the parasites having been obtained from this case the precise type is unknown, but it may be inferred that they were, as in the others of the series, examples of *uncinaria americana* (Stiles).

CASE II.—S., male, aged twenty-nine years; pharmacy student; home in Leon County (139), but prior to coming to Galveston to attend school he spent some months as a logger in a saw-mill in Angelina County (142). In the latter employment he was constantly handling dirty logs, and at this time was often forced to drink creek and "branch" water. At his home his drinking water was obtained from a surface well. Aside from the questionable water supply in Angelina County, no distinct dietetic faults were known. At no time in his life did he recall having had an eruption comparable to "ground-itch." While employed in Angelina County his health deteriorated to a marked extent; he lost not less than thirty pounds in weight, became decidedly anæmic, short-breathed, and much bothered with constipation. He had during this period no definite malarial attacks; but the day before he applied to the writer he had a severe paroxysm. At time of examination in March, 1901, he weighed about 170 pounds (probably ten or fifteen pounds less than his usual weight), was somewhat sallow, and complained of considerable malaise. Blood examination here again failed to reveal the presence of the malarial parasite; but, as in the former instance, a moderate eosinophilia was noted, and, for the same reason as in the previous case, a specimen of the patient's fecal discharge was asked for. The following day a small number of ova of the hookworm were discovered in the stool. Repeated examinations of the blood subsequently failed to show the presence of any malarial organisms; but early in the following vacation there was a second malaria-like paroxysm, after the subsidence of which the patient has remained to the present entirely free from this feature. On April 23, 1901, ninety grains of thymol were administered, with the usual precautions as to abstinence from alcoholics and oils, after a night's fasting, and followed by a dose of salts after an hour from the last dose of thymol. The stools were collected, washed through a sieve of cheese-cloth, and two female examples of the *uncinaria americana* (Stiles) were obtained. Owing to press of class work the writer was unable to give attention to complete blood study in the case, as was desirable, but put aside several smears for a differential leucocyte count. This latter shows an eosinophilia of 10 per cent., a marked increase of lymphocytes (40 per cent.), with a corresponding decrease in the polymorphonuclear elements (40 per cent.); large mononuclear cells, 8 per cent. There are to be seen in the specimens frequent examples of altered red cells and of polychromatia; apparently, too, judging roughly from both stained and fresh preparations of the blood there existed a distinct relative leucocytosis; but without exact method, it is, of course, unsafe to insist upon this feature.

Subsequent examination of the stools failed to exhibit the presence of more ova, and from the time of the discharge of these few worms, with the single exception of a chill and fever during the following vacation (for which quinine was at once given and which never recurred), the patient rapidly and fully regained his health and weight.

Although in this case so few of these worms were obtained that the writer has been forced to accept the idea that these could not have caused the symptoms mentioned above, yet it is to be kept in mind that possibly, by some fault in the collection or examination of the stools (which is not appreciated, however), a considerable number of the worms were lost. Or else it may be that the few actually found represented only the remnants of what was once a more serious number in the man's intestine. It seems not impossible that there may have been originally, probably at the time of the marked loss of flesh and the anæmia noted as having been present when the patient was working in Angelina County, a much greater number of the parasites than were obtained from the stools after thymol, and that the two actually found were the only ones remaining of such a really serious infection, and in this sense it is not improbable that much of the symptom-complex narrated may have been due to these parasites. At least the rapid and complete recovery of the patient's former health and vigor and the total disappearance of the abdominal discomfort after relief from these few worms would not be inharmonious with such an idea.

Case III.—G., medical student; aged twenty-one years; stockily built; sallow; a resident practically all his life in Red River County (77), working in the intervals of his school duties upon his father's farm and in a cotton gin. Three years prior to the discovery of the uncinaria ova in this case the patient had gone on a long wagon trip through the northern tier of counties of the State, west as far as Haskell County (52), thence northeast to Wilbarger County (35), thence along the Brazos River to Young County (54), and east in a somewhat tortuous route to his home—a trip of over 500 miles, during which time the water supply was uncertain and usually bad, taken from surface wells, ponds, creeks, and similar sources. At his own home the water supply was derived from cisterns, and in Galveston, since his first entrance into the medical school, from cisterns and deep artesian wells. Early in his life, from his ninth to his twelfth year, he had suffered from an obstinate diarrhœa, but had quite recovered from this, and for some years his health had been perfect. Since the Haskell County trip, however, he had noted continuously more or less abdominal disturbance: diarrhœa alternating with constipation, with occasionally small amounts of blood distinguishable in the feces, and usually more or less abdominal discomfort if not actual pain. In this case there is the history of the habit of chewing raw cotton in the gin when the patient was engaged at work in the gin, but nothing more nearly approaching the "dirt-eating" habit; there is no history of "ground-itch." During the summer and fall of 1900 (the year preceding the discovery of the parasites) the man was somewhat pale and weak, and because of the indefinite abdominal disturbance suspected the presence of intestinal parasites of some sort. During the same time there were occasional irregular paroxysms as from malaria, promptly ceasing upon the administration of quinine, but invariably reappearing if the drug was left off. This continued until in February of 1901, when the hæmatozoa were sought for and found without difficulty, and a persistent and thorough dosage with quinine was instituted, since when there have been no further disturbances of the sort. During this period, too, the patient noted the development of a shortness of breath and slight swelling about the ankles without any important change in the urine. On May 7, 1901, in the routine examination of samples furnished by the class a number of hookworm eggs were found in the patient's feces; and on May 26th, after the administration of thymol, as in the preceding case, twenty-four examples of the *uncinaria americana* were obtained. Subsequent examination of the stools failed to show the presence of more ova; and to date of writing the patient, now a fourth-year medical student, has recovered entirely from all his symptoms, has increased markedly in weight, his color fully returned, all signs of circulatory and alimentary fault having entirely disappeared. A blood examination made at the time of examination, or shortly after, showed a decrease of the red cells to 4,100,000; white cells, 8000; hæmoglobin, 90 per cent. Unfortunately, the slide preserved for differential leucocyte count was mislaid, but there was a distinct but not very great eosinophilia evident.

The habit of cotton-chewing referred to in this case is mentioned because it is, perhaps, allied to the habit of dirt-eating noted in an important proportion of hookworm cases. It would give but little opportunity for belief in it as a means of transmission of the embryonic worms, which would surely be killed by desiccation if long in the dry cotton. The habit here is probably no more than a secondary pica, as the pica of chlorosis; and probably in many dirt-eaters the habit should be looked on in much the same light, although, according to the prevailing views as to the life-history of the parasite, it is possible, of course, that at times the habit may be the basis for actual transmission of the embryos to the human alimentary canal.

CASE IV.—T., male; junior pharmacy student; aged twenty-one years; residence in Bastrop County (179), where he has lived continuously since birth, save that during his school vacations he has travelled over the greater part of the State, but has never been beyond the State limits. At his home the source of drinking water has been from a well sixty feet in depth; water calcic. Has had no important acute sickness for years prior to the discovery of the parasites in question, but has been subject to griping abdominal pains as long as he can recall (could never eat fruit, especially apples, in the evening without bringing on an attack of this sort, but would always find prompt relief from a little spirits of camphor). No chills for at least ten years; no diarrhœa. Three years before the discovery of the parasites he lost nineteen pounds in weight from some unknown cause within a period of two months, but regained the loss during the following winter. Eight or ten years prior to the time of discovery of the parasites his legs and ankles were frequently extremely painful, and often swelled; but these symptoms have not been noticed at all in recent years. Intestinal discharges were habitually firm; never noticed blood admixture. No dirt-eating habits; but the gentleman recognized the possibility of contamination of food from his dirty hands in the course of his farm work at home. There is no history of "ground-itch."

On May 8, 1901, numerous eggs of the hookworm were found, along with vast numbers of trichomonads, in the discharges of this individual in the course of the routine examination of samples submitted by the class; and on May 21, 1901, after the administration of ninety grains of thymol, with the usual precautions, 202 samples of the *uncinaria americana* (Stiles) were obtained. It was from samples from this case that material was sent to Dr. Stiles, upon which he has based the recognition of the American species of hookworm, a type placed in the museum at Washington being from the same case; specimens from the same case being used in preparation of the drawings illustrating the present article. At time of examination the patient was a tall, spare, sallow young man, with a blotchy complexion, with a slow, weak type of movement, and with a habit of expression much as described by Stiles (*sup. cit.*) as characteristic of medium infections. There were no evidences of the existence of any important disease, and, because of press of other work in connection with the final school examinations, no blood examination was made. The patient left Galveston the day after the discharge of the parasites; in personal letters he has stated that for some weeks he felt unusually weak, and during the summer he passed through a prolonged febrile course mentioned in his letter as "slow fever." On October 24, 1901, a letter from the patient stated that he had never entirely regained his flesh and strength after this fever, but that his color was slowly returning.

Case V.—McC., white; male; medical student; aged twenty-four years. During the past five years has lived for the most part in Texas, but, as a railroad operator and as a ranche hand, has been in the Indian Territory, Louisiana, New Mexico, Mexico, and Colorado, as well; and in his wanderings has frequently been forced to drink water from very questionable sources. For years he has been in exceptionally good health, except for an eruption of the nature of a giant urticaria, at one time diagnosed by a physician in New Orleans as angioneurotic œdema. For years he has had no malarial paroxysms (but, it should added, shortly after the discovery of the ova of the uncinaria in his stools he had a slight chill, for which, without attempting to find the hæmatozoa, he treated himself with quinine, and has had no recurrence). For two years prior to the discovery of the ova he has suffered from attacks of painful diarrhœa, alternating with periods of obstinate constipation, with occasional small amounts of blood in the stools, which were usually light-colored and soft. No history of "ground-itch;" no dirt-eating habits (save the possibility of conveying dirt to his mouth from his hands when the latter were unclean from work). At time of examination of this case there were no symptoms of importance; very few ova were found at this time (May 8, 1901), along with many trichomonads and a few paramœcia, and at the request of the writer the patient consented to refrain from attempting to get rid of the parasites, in order that some idea might be obtained from the case as to their natural persistence in the intestine. At irregular intervals the stools have been re-examined, the last successful examination having been in the autumn of 1902, the first failure during the Christmas holidays of 1902; at time of preparation of this article (May 3, 1903) a very careful search was again made, but without success, although during the entire interval, and at present, the infusoria noted in the first examination have been encountered. A differential leucocyte count in a specimen of blood obtained at the time of discovery of the ova indicates the following proportions of the white blood cells: eosinophiles, 5 per cent.; small lymphocytes, 23 per cent.; large lymphocytes, 4 per cent.; polynuclear neutrophiles, 68 per cent. No count of red and white cells was made at the time of the original examination; recently a blood count was made in which a plethora of red cells existed, 5,680,000; white cells, 7600; hæmoglobin (Dare), 90 per cent. There have been no symptoms in the interval referable to the presence of the worms, and their disappearance has seemed to have had no effect on the urticarial eruption above mentioned, and none upon the abdominal symptoms narrated.

CASE VI.—On May 9, 1902, in a yellow, clay-like, and mushy stool from a senior pharmacy student, C., a small number of hookworm ova were encountered, together with a few amœbæ and numerous trichomonads. Mr. C., aged twenty-three years, is a resident of Houston County (141), and prior to the above date had never been beyond the limits of the State. Within the past five years he has, in addition to his life at home, lived six months in Huntsville (83), ten months in Runnels County (134), twenty-four months in Galveston, and four months in Lufkin (142), Texas. At his home the source of drinking water was from surface wells; the same in Runnels County; in Lufkin, underground cisterns and surface wells; in Huntsville, overground cisterns and artesian wells; in Galveston, the same. His habits and occupation as a drug clerk give no trace of any dirt method of infection. In general his health has been good for many years; has had no more than two or three chills during the five years prior to examination of stools, and these responded readily to quinine and were regarded as of malarial origin (but without blood examination to verify this belief). Has had no important losses in weight. During the winter preceding examination has noted periods of mental dulness, supposed to have been occasioned by mental fatigue from close study, and suffered slightly from an intermittent diarrhœa. At time of examination Mr. C. was apparently in good health; his complexion clear, with a slight pallor (no more, however, than is common to persons accustomed to an indoor life for years), and with a frequent play of color suggesting a vascular ataxia (the latter a symptom of long standing). No other symptoms of importance could be made out. Leucocyte count from smears taken at this time give the following: eosinophiles, 22 per cent.; small lymphocytes, 16 per cent.; large lymphocytes, 2 per cent.; polynuclear neutrophiles, 60 per cent. On June 11, 1901, after administration of ninety grains of thymol, with the usual precautions, followed by salts, four specimens of the *uncinaria americana* (Stiles) were obtained; and subsequent examination of the stools failed to show the presence of ova. Personal letters from Mr. C. inform the writer that since the above there have been no important features of any type developed in the case.

CASE VII.—J., white; male; aged twenty-four years; medical student; residence in Harrison County (95), where he has lived for more than five years prior to the date of examination resulting in the discovery of the parasites in question, for the most part in the town of Marshall, not having been without the bounds of the county in the same length of time, save when in Galveston pursuing his medical studies. The water supply of Marshall is from artesian wells sunk some five miles away from the town; when in the country (Harrison County) the patient's water supply was obtained from springs and from surface wells; in Galveston the water was obtained from the city artesian supply. There was nothing in the history of the case suggesting any dirt habits in the acquirement of the hookworms, and no history of ground-itch. In the summer of 1900 he had chills (no blood examination) which yielded for the time readily to the use of quinine. During the fall and winter of 1900 and 1901 the chills recurred, and on several occasions the tertian parasite was discovered. These chills continued irregularly up to the time of discovery of the ova in the stools, although during the same period he continued with more or less regularity the use of quinine. During the same period he suffered from an intermittent diarrhœa (stools dark and sometimes almost liquid, without gross appearance of blood admixture), alternating with a few days of constipation from time to time. During this time and up to the date of discovery of the hookworm ova he lost fourteen pounds in weight and became somewhat anæmic in appearance. On May 9, 1901, ova of the hookworm were found in large numbers in the stool in the routine examination of fæces from the various students; and on May 19th, after administration of thymol and salts in the usual manner, there were obtained 389 examples of the *uncinaria americana* (Stiles). Subsequent examinations revealed no further presence of ova in the discharges. Subsequent to the removal of these parasites the patient had one chill, and was at once given quinine in full and persistent dosage, from which time to the present he has been entirely free from further attacks of this type. From this time onward the patient rapidly regained his former health and weight, and his usual ruddy complexion returned. In blood examinations made for the malarial disturbances prior to the examination of the stools it had been noted that there was present a moderate leucocytosis, but not any marked diminution of red cells, and the eosinophile cells were apparently increased (but no differential count of leucocytes was made). Through a misunderstanding, the patient, an advanced student who was to have made for the writer an estimate of the blood cells before taking the anthelmintic, did so after the worms had been discharged, in which examination a distinct and interesting plethora of red cells was recognized (6,100,000), probably due to the withdrawal of a distinct part of the watery element of the blood; at the same time the leucocytes were distinctly increased (20,000 to the cubic millimeter).

CASE VIII.—G., white; medical student; aged nineteen years; a resident of Austin County (244); has never been outside the State limits; has lived for two years in Galveston, as required in his medical work, and for a short time, during vacations, in Lavaca County (207). In both of the latter places the source of drinking water was from artesian wells (in Galveston also from overground cisterns), and at his home from surface wells. There was nothing in the patient's history bearing on the acquirement of the parasites through dirt habits, unless through the eating of raw garden vegetables, which might, possibly, at times not have been sufficiently well washed; the patient recalls that several years prior to the discovery of the ova in the stools he had had a severe "ground-itch" about the hands and wrist, supposed to have been acquired from the garden ground in which he was then employed for a large part of his time. In 1900, while living in Austin County, the patient had for about five months suffered from a severe indigestion, but had had no diarrhœa or pain of importance in connection with the attack. About this time, too, he had had a number of malarial paroxysms, which always were checked by the use of quinine, until after he came in the fall of the same year to Galveston to college. In the latter city a blood examination revealed the presence of the tertian parasite, and in spite of persistent treatment with large doses of quinine the affection grew worse. At the time of examination (May 21, 1901) the man was slightly anæmic, his complexion blotchy, and he exhibited an unusual degree of tremulousness of the hands and face; there were no appreciable respiratory symptoms; no vascular or circulatory disturbances; he complained of easy physical fatigue and mental tire; slight, dull, uncomfortable feeling, general throughout the abdomen; no important digestive failure; no urinary symptoms. On May 21, 1901, a number of uncinaria ova were found in his stool, and on May 24th ninety grains of thymol were administered, resulting in the recovery from the stools of sixteen examples of the *uncinaria americana.* Subsequent examination of the stools failed to reveal further presence of ova. Differential leucocyte count in smears, taken just before the administration of the thymol, showed the presence of an eosinophilia of 12 per cent.; small lymphocytes, 20 per cent.; large lymphocytes, 6 per cent.; and polynuclear neutrophiles, 62 per cent. After taking the thymol and continuing the use of the quinine as before, there occurred two further chills, after which the entire symptom group referable to malaria completely disappeared; and to the present the patient has been steadily improving, having lost all symptoms save his tremulousness, which is no longer comparable, however, to its former degree.

UNCINARIASIS IN THE UNITED STATES. At the time of the discovery of the parasites in the above-mentioned cases it was not suspected that there existed in man any other species of the hookworm than that first described by Dubini[1] in 1843, under the name *anchylostoma duodenale,*[2] and the few cases published from the United States had been invariably spoken of as if identical with this old-world species—a belief which, in the light of our present knowledge, is a matter of more or less doubt for the individual cases. So, too, although a foreign importation was at least suggested in such cases, it is equally a matter of doubt whether the parasites were not really obtained in the localities where found. Certain writers speak of its recognition (referring to *uncinaria duoden-*

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[1] Annal. univers. di med., April, 1843, vol. cvi. pp. 5-13.

[2] In this paper the writer has employed the term *uncinaria duodenalis* (Dubini) Railliet, 1885, as the proper generic and specific name of the old-world hookworm, more commonly spoken of as *anchylostoma duodenale,* Dubini, 1843. The generic title *anchylostoma* was preceded by that of *uncinaria* (Froelich, 1789) for those meromyarial strongyloid worms whose anterior extremity is curved dorsally into a hooklike shape. The division into the proposed genera *uncinaria* and *anchylostoma,* resting mainly on the absence or presence of distinct hooks upon the rim of the buccal capsule, seems scarcely justifiable; the gradation is clear from *uncinaria canina,* with its bilateral ventral trios of such "teeth, to *uncinaria duodenalis,* with its bilateral pairs of similar structures in the same position, to *uncinaria stenocephala,* with its bilateral single large tooth springing from the lower surface of a prominent ventral lip, to *uncinaria americana,* with its bilateral large ventral chitinous untoothed lip, indicating that such a lip in the last-named worm is but a simplified representative of the more complex buccal armature of the previously mentioned examples, possibly the primitive type of such armature. For this reason, until other data justifying the division of the original genus be brought forward, the writer would prefer to retain all the group possessing buccal armature consisting either of prominent lips or hooklike teeth under the generic classification here adopted.

alis) in America at an earlier date than the publication of Dubini,[1] but it is doubtful whether any of the earlier American writers, while probably discussing cases of uncinariasis, had any idea of the real nature of the affection. In this category are to be placed the writers named in the above references, Chabert (1830) and Duncan (1840) in Louisiana, Lyell (1843) in Alabama and Georgia, Heusinger and Geddings in South Carolina, and Little and Letherman in Florida. As far as the writer's knowledge extends, the case of Herff (*sup. cit.*), in 1864, in San Antonio, Texas, which was possibly of Mexican origin, was the first recognized in the United States; and in this case the recognition was uncertain, but probably correct for one or other species of the hookworm. (The specimens shown by White[2] before the Boston Society for Medical Improvement as examples of *uncinaria duodenalis* were Brazilian in origin, having been obtained from a patient of Dr. Wucherer, of Bahia, and their specific classification is at this time uncertain.) Blickhahn's case,[3] reported as *uncinaria duodenalis* in 1893, from St. Louis, Mo., was the first positively recognized in this country; it occurred in the person of a brickmaker, seventeen months in the United States from Germany, and was supposed by Blickhahn to have been imported from the latter country. Probably the actual recognition of the endemic existence of the hookworm in this country rests in the discovery of the ova in 1895, as above mentioned, by the writer; but the failure in that instance to discover the host made it undesirable to give any publicity at this time of the fact, and, of course, no strict priority can be claimed because of the failure of publication. Moehlau,[4] in 1897, reported five cases (more recently the subject of some doubt) as examples of *uncinaria duodenalis*; and the infection here was supposed to have been imported or to have followed imported cases. Gray,[5] in 1898, encountered a case determined as *uncinaria duodenalis* and known to have developed in Virginia; and in 1899 Tebault[6] described a case which was probably due to the American species, undoubtedly arising in New Orleans. Cases of Porto Rican origin were reported from New York by Ashford,[7] from Baltimore by Hemmeter,[8] and by Boston,[9] of Philadelphia, as having been recognized in 1900. All of these cases, were probably of the American type of the hookworm. Early in 1901

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[1] Dolley. Annual of Univers. Med. Sci., 1891. Blanchard, Traité de Zoologie Méd., vol. i., p. 769.

[2] Boston Medical and Surgical Journal, vol. lxxv. p. 427.

[3] Medical News, vol. lxiii. p. 662.

[4] Buffalo Medical Journal, March, 1897.

[5] Virginia Medical Semimonthly, September 27, 1901.

[6] New Orleans Medical and Surgical Journal, September, 1899.

[7] New York Medical Journal, April 14, 1900.

[8] Stiles. Eighteenth Annual Report Bureau of Animal Industry, U. S. Dept. of Agriculture, p. 210.

[9] Allyn and Behrend. American Medicine, July 13, 1901.

Dyer[1] reported a case of certain domestic origin, probably of the American type of parasite. In the same year a case was recognized in Albany, N. Y., as *uncinaria duodenalis* of Philippine origin, by Ward,[2] and a second, probably of Italian origin, by Neuman.[3] The case reported by Dr. M. C. Schaefer[4] from Galveston, in April, 1901, before the Texas State Medical Association, was undoubtedly of Mexican origin. It was reported under the name *anchylostoma duodenale* (*uncinaria duodenalis*), but the writer has, since the establishment by Stiles of the species *uncinaria americana*, definitely identified it with the latter. It was discovered in February, 1901. In the paper of this author the writer's first two cases were mentioned, both later identified as *uncinaria americana*, both having been found in March of the same year. In May of 1901 the remaining six of the above series described in this paper were encountered, these, also of the American species; and later in the year two more cases of the same type, not yet published, were found in the wards of Galveston hospitals by Dr. J. T. Moore. Shortly after the cases of the writer's series, Claytor met with a case of *uncinaria americana* originating in Virginia,[5] and quickly following appeared the discovery of a case of *uncinaria duodenalis* of Italian origin in Philadelphia, by Allyn and Behrend.[6] Later in the year the case of Hall[7] and Yates[8] was published, having been encountered in the person of a sailor usually travelling between England and the United States, but who had recently been in Vera Cruz, Mexico; this proving to be a case of the old-world hookworm. Still later in 1901 Bailhache[9] described a case from New York, of uncertain species and of uncertain origin (South America?).

Subsequent to these reports of hookworm in this country, publications of similar discoveries in a wide range in the United States have appeared, principally in the Carolinas, Georgia, Florida, Alabama, and Texas, but also from Illinois and California—although the reports from the latter States would indicate the infection to have taken place in Panama, the Philippines, Mexico, and Porto Rico, and at least one case to have been an instance of *uncinaria duodenalis*.[10] Of these publications none approach in importance the bulletin of Stiles, who, as zoölogist of the United States Public Health and Marine Hospital Service, has added much the greater part of our knowledge of the distribution and influences of the American type of hookworm. To Stiles, too, is due entirely the credit of establishment of the species *uncinaria americana* and its exact differentiation from the previously known *uncinaria duodenalis*, using as material specimens from Porto Rico and Ashford's cases, from Claytor's Virginia cases, and from Case IV. of the writer's series from Texas.[1] The same author, basing his opinions upon theoretical grounds, obtained in his studies in comparative parasitology and a few cases reported from this country, had in 1901[2] called attention to the probably wide prevalence of hookworm disease in man in the southern parts of the country, a position amply proved by his own brilliant discoveries and the added testimony of others during the past year.

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[1] Interstate Medical Journal, March 15, 1901.

[2] Albany Medical Annals, January, 1903.

[3] Stiles. Eighteenth Annual Report Bureau of Animal Industry, U. S. Dept. of Agriculture, p. 215.

[4] Trans. Texas State Medical Association, 1901; note in Texas Medical News, May, 1901; Medical News, October 26, 1901.

[5] Philadelphia Medical Journal, June 29, 1901; THE AMERICAN JOURNAL OF THE MEDICAL SCIENCES, January, 1902.

[6] American Medicine, July 13, 1901.

[7] Journal of the American Medical Association, November 30, 1901.

[8] Johns Hopkins Hospital Bulletin, December, 1901.

[9] Stiles. Eighteenth Annual Report Bureau of Animal Industry, U. S. Dept. of Agriculture, p. 215.

[10] Stiles. Bull. No. 10, Hygienic Laboratory, U. S. Public Health and Marine Hospital Service, February, 1903; Herrick, American Medicine, July 19, 1902; Harris, ibid., July 19, and November

From personal study of examples of the parasites obtained from the cases detailed above, the writer was aware of a distinct difference between these worms and *uncinaria duodenalis*, and from some similarities to *uncinaria stenocephala* of the dog was at first inclined to believe the parasites of Dr. Schaefer's case and of Cases I. and II. of the above series found in the Texas medical students to be a variety of the latter, and that perhaps dogs bore some part in the disease and its prevalence among men. After the publication of Stiles, announcing the species *uncinaria americana*,[3] no difficulty in establishing the identity with the latter of the parasites in all the Texas cases was experienced. Thus far, in these and other cases coming to his knowledge in this State no examples of *uncinaria duodenalis* have been recognized.[4] So, too, the majority of specimens met in the southern United States generally, in Porto Rico and elsewhere in the West Indian Islands, and at least some of those originating in Mexico and elsewhere in Spanish America are known to belong to the same species; which, hence, must have a wide American tropical and subtropical range of distribution, and which there is reason to believe has been carried thence into other parts, as into the Philippines, and, possibly, into the Spanish peninsula in Europe by travel.[5] In these Spanish and Portuguese-American districts

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15, 1902; Smith, ibid., June 21, 1902; Capps, Medical News, November 29, 1902, Journal of American Medical Association, January 3, 1903; and Brown, Occidental Medical Times, March, 1903.

[1] Type specimen No. 3310, Bureau of Animal Industry, U. S. Dept. of Agriculture.

[2] Texas Medical News, July, 1901.

[3] American Medicine, May 10, 1902.

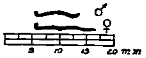
[4] Since writing this paper the author has encountered, in July, 1903, a case of pernicious anæmia dead from the old-world hookworm, which he proposes to use in a further paper as a basis of comparison with *uncinaria americana*.

[5] As a matter of scientific interest it should be inquired into whether possibly the reverse of the above idea may not be true, *i. e.*, whether *uncinaria americana* may not be an East Indian parasite which was perhaps carried into tropical America with the ancient inhabitants, who

there are also to be met instances of the old-world hookworm, probably brought in a similar manner from Europe to this continent. From our present knowledge of the influences of the parasite, it seems certain that many of the early references by American writers to endemic anæmias associated more or less with the dirt-eating habit are to be correlated with uncinariasis, and it, therefore, is not unreasonable to think that, probably, the worm was endemic among the aborigines of the above-mentioned areas of America, and was transmitted by them to the whites, and thus to the present occupants, generation by generation.

Description of Uncinaria Americana (Stiles). Superficially, *uncinaria americana* (Stiles) bears close resemblance to *uncinaria duodenalis*, differing mainly in the nature of the buccal armature; it is somewhat smaller, as a rule, but individual instances attain the lower measurements named for the old-world parasite; there are also slight but important differences in the sexual bursa and its rays in the male worms, and the ova of *uncinaria americana* are larger than those of *uncinaria duodenalis*, and are apt to be found in more advanced embryogenesis

Fig. 2.



Showing actual size of male and female uncinariæ.

These worms are nematodes of the family *strongylidæ*, subfamily *strongylinæ*, genus *uncinaria.* They are elongate, cylindric, tapering in both sexes toward a blunt head end, and having the anterior extremity curved dorsally, this giving the characteristic " hook " type of the genus *uncinaria.* The posterior extremity of the female is mucronate; the male ending suddenly in a blunt tip, without gradual contraction, within the caudal bursa. The color is whitsh or cream-colored, sometimes the contents of the alimentary canal giving the worm a slightly brownish tint in the middle half. In their thickest part they average 0.4 mm. in thickness, ranging from 0.3 to 0.6 mm.; the males are usually 7 to 8 mm. in length, ranging from 6 to 9 mm.; the females usually 10 to 11 mm. in length, ranging from 8 to as much as 14, or even 15 mm. occasionally (Fig. 2). The measurements given by Railliet[1] for the male *uncinaria duodenalis* are 8 to 11 mm. in length, females, 10 to 18 mm.

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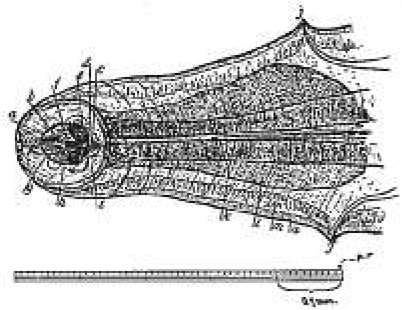
are more or less generally regarded as the progenitors of the South and Central American and Mexican races of American aborigines. Could a marked predominance of this species be established as existing in Eastern Asia and the Pacific archipelagos, particularly in the relatively uncivilized Pacific islands, it would not only be of importance from a point of medical geography but also would prove a valuable item in ethnography.

[1] Traité de Zool. Méd. et Agric., Paris, 1895, p. 465.

The mouth opening is directed dorsally, and is to be seen only in specimens arranged to exhibit the dorsal side of the head (Fig. 3). It is formed by the delicate, transparent cuticle, which here becomes continuous with the lining of the buccal cavity. It is of an elliptical shape, its long axis directed anteroposteriorly, measuring 50μ to 70μ in long axis, and 40μ to 50μ transversely (but varying considerably in different specimens, and, undoubtedly, in life capable of considerable contraction and expansion). The walls of the buccal cavity are supported throughout the greater portion by a chitinous capsule of a cup shape. This is composed of at least four pieces, two large curved lateral plates incompletely separated along the dorsomedian and ventromedian lines, a thin, curved quadrilateral plate placed internal to the dorsal line of separation of the lateral plates (dorsal extension of dorsal conical tooth), and a thickened marginal ring serving as a rim to the cup, also incompletely divided dorsally and ventrally. The latter bears on each side of the capsule two lips, the larger ventral lip (the analogue of the ventral hooklets of *uncinaria duodenalis*) projecting into the buccal space beyond the margin of the true mouth, the smaller dorsal lip extending close or quite to the margin of the latter. Beneath (toward the base of the capsule) these lips on each side of the capsule may be seen three papillæ projecting into the cavity, the ventral and lateral directly beneath the large ventral chitinous lip, the smaller beneath the smaller dorsal lip about its middle. These papillæ are covered by the oral membrane which rises in longitudinal folds

FIG. 3.

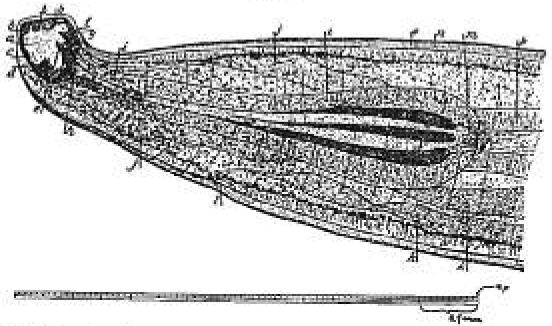


Dorsal view of cephalic end of *uncinaria americana*. *a*. Oral cuticular margin. *b*. Large chitinous ventral lip. *c*. Smaller chitinous dorsal lip. *d*. Dorsal conical tooth. *e*. Lateral lancets. *f*. Ventral lancets. *g*, *h*, *i*. Oral papillæ. *j*. Cervical papillæ, with ductus of cervical glands. *k*. Muscular wall of œsophagus. *l*. Œsophageal glands. *m*. Muscular layer of body wall. *n*. Cuticle.

from below upward to the apices of the papillæ, giving rise to faint lines from the pharyngeal armature toward the rim of the buccal capsule. In some specimens the papillæ appear spiculated at the tip.

The shape of the buccal capsule may be apprehended from the accompanying drawings of the dorsal and lateral views of the head (Figs. 3 and 4). Viewed from the dorsum it is seen to have at the rim an almost circular outline, and deeper in the cavity to be slightly elliptical, the transverse diameter being slightly larger than the dorsoventral. Viewed laterally the rim of the capsule is nearly straight, in general parallel with the long axis of the worm, while the ventral line is the longest and most curved boundary, the line of the base being nearly straight and directed in nearly a right angle to the line of the rim. A short, straight dorsal limit connects the rim with the dorsal end of the base line. There is some variation in the measurements in different specimens; but, as a rule, the distance from the extreme depth of the buccal capsule to its rim is 100μ; the dorsoventral diameter (outer lines) at the widest part is about the same, the transverse diameter being equal to the latter at the upper part and slightly greater in the broadest portion, deeper within the cavity.

FIG. 4.



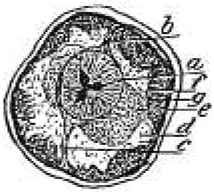
Lateral view of cephalic end of *uncinaria americana*. *a*. Buccal cavity. *b*. Oral papillæ. *c*. Chitinous capsule. *d*. Ventral lancets. *e*. Lateral lancets. *f*. Dorsal conical tooth, with (*g*) its posterior extension reinforcing part of capsule. *h*. Interior of œsophagus; its chitinous wall continuous with the pharyngeal teeth above. *i*. Muscular wall of œsophagus. *j*. Œsophageal glands opening into the pharynx. *k*. Cervical glands opening externally at cervical papillæ, *l*. *m*. Trilobed valvular opening of œsophagus into intestine. *p*. Intestine. *n*. Muscular layer of body wall. *o*. Cuticle.

Through the base of the capsule rises the chitinous lining of the pharyngeal portion of the œsophagus with the peculiar pharyngeal armature of the worm. This consists of certain chitinous tooth-like structures joined more or less in continuity by reflections of the lining membrane of the cavity, so as to form a funnel-like opening supported by the chitinous projections. There are five principal chitinous elements, with several small intermediate ones, set into the chitinous wall of the pharynx. Of these the most striking and unvarying in position is the so-called "dorsal conical tooth," set in the dorsal wall and reinforcing by its dorsal plates the break in the dorsal wall of the buccal capsule (Figs. 3 and 4). It is composed of a chitinous plate rising well into the buccal capsule cavity, arched from side to side so that the dorsal surface is slightly convex, while at the median line a groove in the dorsal side causes a slight longitudinal fulness on the ventral surface, in some positions giving the impression that the tooth is longitudinally divided. The plate rises to a pointed tip, and, as it does so its sides fold dorsally and again rise back of the tooth as a reinforcement of the posterior wall of the capsule, and bear a fold of the oral membrane, which thus dorsally envelops the tooth. The other four chitinous elements are symmetrically arranged, two on either side of the median line. The laterals are to be seen on either side and close to the dorsal conical tooth, each rising as a thin conical projection with spiculated tip (thus in lateral views—from above downward or dorsoventrally, more widely conical), evidently moving transversely and slightly dorsoventrally in projection and retraction of the œsophagus. These receive the fold of membrane from the dorsal plates of the dorsal conical tooth, and are connected by similar and deeply curving folds with the ventral teeth. They are apparently also connected with each other by a similar fold extending transversely and on the ventral side of the dorsal conical tooth, this fold forming the dorsal boundary of the pharyngeal funnel. The ventral teeth, known as the ventral lancets, are broadly conical when viewed laterally, narrower when seen from above downward or ventrodorsally. When everted they lie close to the curved ventral boundary of the buccal capsule, one on either side of the median line, a deep groove separating them, save where a loose low fold of the oral membrane extends between them to form the ventral border of the pharyngeal funnel. Laterally, a fold passes from each to join the neighboring lateral tooth, forming the low lateral margin for the funnel of the pharynx. These ventral lancets are moved in action toward the dorsal conical tooth and from above downward, with possibly a slight lateral play. They are spiculated at the tip.

In effect this arrangement is admirably adapted to the suctorial habits of the worm. When the œsophagus is forced forward into the base of the capsule the pharyngeal membrane and its attached chitinous teeth are everted to form a rather wide funnel, into which is drawn a tiny part of the intestinal mucous membrane of the infected individual when the worm is feeding; the œsophagus is then retracted, bringing the tips of the ventral lancets dorsally and downward and the tips of the lateral teeth toward the median line on the ventral side of the dorsal conical tooth (Fig. 3). The latter in this movement is drawn slightly ventrally, but is apparently less motile than the other elements. Close about the bit of tissue thus grasped the membranous pharyngeal border is drawn, insuring efficiency of suction from the tiny wounds inflicted by the action of the chitinous teeth. Doubtless in grasping the mucous membrane of the host the whole capsule with its chitinous lips and papillæ plays an important part, movements of retraction of the œsophagus at the base of the buccal capsule tending to spread the transverse diameter of the buccal rim, and protrusion of the œsophagus into the base widening the latter and narrowing the rim; the alternate capsular and pharyngeal action suggesting a high degree of service in the work required.

From the above description it may be readily apprehended that much confusion is to be expected in the study of this apparatus, either in sections or in the undivided head; the relative position of the teeth and pharyngeal membrane varying so as to present quite different appearances of detail in different specimens, even in practically the same plane of section or in the same direction of examination. Probably the easiest mode of study is obtained by dividing the neck as close as possible to the head, so as to relax the œsophageal structures, when the pharyngeal funnel and its chitinous elements are likely to assume a fairly separated and distinct position for observation. By careful manipulation such a head may be studied in water, with and without a cover, in its different aspects without much difficulty.

FIG. 4.

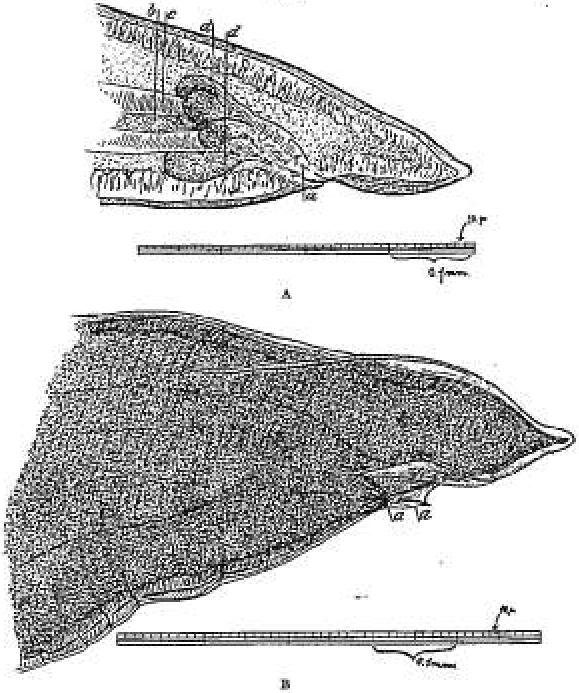


Transverse section of upper œsophageal valvular expansion, showing triradiate appearance of interior. *a.* Œsophagus. *b, c.* Dorsal and ventral muscular attachment of œsophagus. *d.* Body space. *e.* Œsophageal glands. *f.* Muscular wall. *g.* Cuticle.

Two glands, the œsophageal glands (Fig. 4), open into the base of the capsule, apparently just within the line of the ventral lancets. These may be presumed to furnish a salivary fluid destined to aid in preserving the fluidity of the blood as it is being drawn from the wounds inflicted by the chitinous teeth, and may possibly have some toxic influence upon the individual infected, and thus be an element in the production of the clinical features of uncinariasis.

Viewing the head from the dorsal aspect the œsophageal opening is seen beneath (ventrad) the dorsal conical tooth as a crescentic opening (convexity directed ventrally), into which the lateral teeth extend from the sides toward the median line; and from the ventral border the ventral lancets extend dorsally across it. It should be remembered, however, that a groove corresponding to the space between the ventral lancets, but hidden by the pharyngeal membrane between these structures, exists, and that, therefore, the opening is really triradiate, an appearance carried into the upper part of the œsophagus (Figs. 4 and 5).

FIG. 6.



Posterior extremity of female *uncinaria americana*.

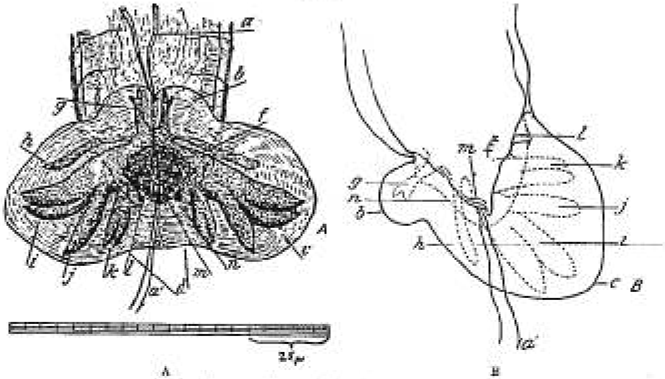
A. Lateral view: *a.* Anal papillæ. *b.* Interior of intestine. *c.* Wall of intestine. *d.* Anal glands.

B. Same subject from a somewhat larger specimen and viewed ventrolaterally, showing anal opening expanded: *a.* Anal papillæ, showing small chitinous tips.

The œsophagus (Fig. 4) is a thick-walled muscular structure, in its upper portion lined internally by chitinous material. It is of an elongate flask-shape, circular in transverse section, its upper end terminating abruptly at the base of the buccal capsule, to which its outer portion is attached and through which the inner part slightly projects into the lower part of the buccal cavity. It is thicker posteriorly than anteriorly, measuring at its thickest part about 150μ to 160μ, and is about 700μ to 750μ in length. At its posterior extremity it opens by a valvular arrangement into the straight, wide intestine.[1]

The intestine opens in the female by an anus guarded by small anal valves close to the tip of the tail on the ventral surface (Fig. 6). In the male it terminates in common with the sexual organs in the blunt tip of the tail lying within the caudal bursa, the opening being on the dorsal side close to the tip (Fig. 7). Externally the worm is covered by a delicate, transparent, and finely transversely striated cuticle

FIG. 7.



A

B

Posterior extremity of male *uncinaria americana.*

A. Dorsal view, bursa spread open and dorsal lobe thrown upward over body of worm: *a.* Inner end of genital spicules. *a'.* External barbed extremity of spicules. *b.* Subdivided dorsal lobe of bursa. *c.* Large lateral lobe of bursa. *d.* Limits of inconspicuous ventral lobe of bursa. *f.* Dorsal aspect of tip of tail within bursa. *g.* Bipartite-tipped dorsal ray. *h.* Dorso-lateral ray. *i.* Divided lateral ray. *j.* Ventro-lateral ray. *k.* Divided ventral ray. *l.* Inconspicuous subventral ray. *m.* Opening of cloaca, with chitinous furcula. *n.* Cuticle of tail.

B. Lateral outline view of same; letters as above.

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[1] In a subsequent paper the writer wishes to describe more fully and exactly the details of the oral parts and the general structure of the worm, and for this reason prefers in the present discussion to pass briefly the features which are non-distinctive of this special parasite.

showing lateral, dorsal, and ventral longitudinal lines, the first being the more distinct. Beneath the cuticle is a layer of muscle, meromyarial, with internal extensions for the support of the intestine, sexual organs, and other structures. On the external surface, about 300 μ back of the base of the buccal capsule on each side of the worm, there is to be seen a rather prominent papilla, at the summit of which opens a duct of a large gland, the cervical gland (Figs. 3 and 4).

The sexual apparatus, particularly the sexual caudal bursa of the male, is of importance in the identification of the species. The female genital opening is apparent on the ventral surface at a point just within the anterior half of the specimen, guarded by two transverse lips forming the sexual valve. From this a short vaginal canal extends internally and divides into the anteriorly and posteriorly directed uterine canals, which lie in a tortuously plicated manner along the intestinal tube. From the extremity of each a narrow tubal continuation forms the ovary, each of the latter ending blindly in the upper part of the worm, the posterior ovarian tube having turned upon itself to attain this anterior termination. Within the uterine canals of the pregnant females are to be seen great numbers of ova in various stages of development and segmentation, in occasional instances the embryo being visible within the shell.[1]

The male sexual apparatus consists of a pair of testicles, long narrow tubes analogous in appearance and disposition to the ovarian tubes of the female, which unite suddenly about the middle of the specimen in a large sac, the seminal vesicle, which in turn opens into a rather large, straight tube (the ejaculatory duct). This continues to the tail of the worm, where it opens in a papilla upon the dorsal side of the tip of the tail (Fig. 7). From this opening, whose sides are supported by a chitinous furcula the cornua of which are connected by a transverse lip, emerge two delicate filaments apparently of cuticular structure, retractile, barbed at the free end, and measuring 0.9 mm. in length (sexual spicules). Surrounding the caudal tip is the sexual bursa, an umbrella-like expansion formed of the folded cuticle, between the folds of which the muscular layer of the body wall sends out a number of finger-like extensions or rays which serve to expand the bursa or bring its lobes in apposition. In the expanded state (Fig. 7, A) this bursa presents a distinctly trilobed outline made up of two large lateral lobes and a partly divided smaller dorsal lobe; while the ventral outline shows a slight curvature forming an indistinctly marked ventral lobe. From about the tip of the tail in the middle of this bursa the rays emerge symmetrically from the body wall; a common base dorsally gives origin on each side of the median line to a small dorsal ray with bipartite tip and a long, slender, slightly clubbed dorsolateral ray (the latter bending into the dorsal portion of the lateral lobe of the bursa; laterally from a common base on each side spring a large, thick, divided lateral ray, a smaller simple ventrolateral ray and a divided ventral ray; near the ventromedian line on each side one may distinguish also a short, single, inconspicuous subventral ray. The ends of these rays are provided with tiny chitin-like tips. Transversely the bursa measures 95μ to 100μ, the dorsoventral measurement being from two-thirds to three-fourths as great according to the degree of expansion obtained in the specimen observed.

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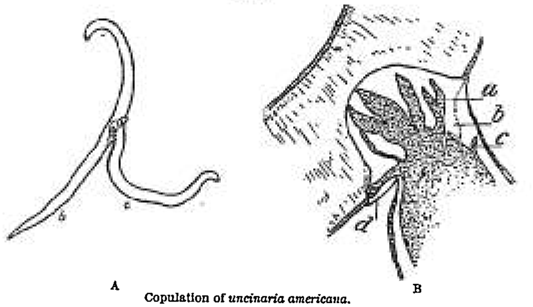
[1] Stiles working over material from Case IV. of the above series observed an instance of this almost viviparous possibility; in material from two other cases the writer has encountered similar appearances. The stools in each of these instances were quite fresh, and numbers of the worms exhibited active movements when obtained, and were at once placed in a formaldehyde solution for preservation.

FIG. 8.



Copulation of *uncinaria americana.*

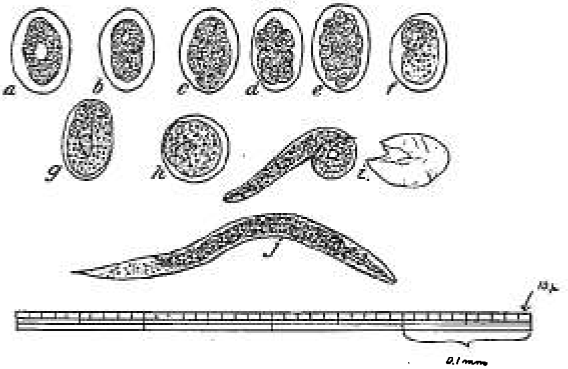
A. Moderately large view of (*b*) male and (*c*) female in coitu.

B. Detail of bursal application of male to body of female, higher enlargement: *a*. Ventral ray of male. *b*. Anterior lip of vagina. *c*. Subventral ray of male. *d*. Dorsal ray of male.

In coitus the male applies this bursa with its muscular rays about the ventral and lateral aspects of the female, so as to bring the sexual papilla in close apposition and slightly penetrating the female opening, the sexual spicules extending into the vaginal and uterine canals. The coitus is prolonged; and occasionally specimens are expelled in congress after administration of the anthelmintic to the host, the bodies of the male and female, together, forming a Y-shaped combination as shown in the accompanying drawing made from a pair thus obtained from T., Case IV. of the above series (Fig. 8).

The ova, formed within the uterine canals of the female worm, are passed through the genital pore in large numbers, and constitute an easily recognizable microscopic element of the feces of the host. No special technique is required for their discovery beyond the application of a small bit of the suspected stool upon a glass slide with a drop of water, if needed, to make the specimen nearly fluid, the adjustment of a cover-slip, and the use of a magnifying power of from 100 to 400 or 500 diameters, as may suit the wishes of the observer. In cases of even but moderate degree one rarely fails to find in the first bit of feces thus examined several of the ova; and in mild cases anyone familiar with the appearances should, with the low power of the microscope, be able to find within ten or fifteen minutes at least, one or more of the eggs in four or five trials. The ova have an elliptical outline (Fig. 9), are colorless, with a thin, transparent covering, and a granular interior in varying degrees of segmentation, or with a small rhabditiform embryo enclosed. They measure in long axis 68μ, transverse 38μ to 40μ, with slight variations above or below these measurements in different specimens, the measurements of the ova of the *uncinaria duodenalis* given by Railliet being 52μ x 32μ.

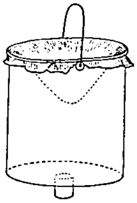
FIG. 9.



Ova and embryos of *uncinaria americana*. *a.* Unicellular ovum. *b, c, d, e.* Ova showing various stages of segmentation. *f, g.* Ova containing larval uncinariæ. *h.* Peculiarly shaped ovum. *i.* Larval worm just emerged from shell. *j.* Larva extended after emergence.

In the recovery of the parasites from an individual in whose intestinal discharges the ova have been found, little difficulty has been experienced by the writer from the use of thymol. Filix mas has been lauded by a number of writers for the dislodgement of the *uncinaria duodenalis;* and in the first case of *uncinaria americana* falling under the writer's observation (the case of S., recorded by Dr. M. C. Schaefer, *sup. cit.*) this was in the beginning employed, but without success. A later use of thymol in the same case was successful in removing one hundred and two specimens of the parasite; but in spite of several repetitions, occasional ova were detected in the stools thereafter. In the series of cases mentioned in the present article thymol was administered in six cases, in all being followed by the discharge of a greater or smaller number of the worms; and in none of these cases were ova discoverable in the stools subsequent to the single administration of the drug. In practice the writer has followed the method of administration commonly employed on the Eastern continent for the old-world hookworm. The patient, either with or without previous light purgation, is given a liquid supper the day before administration of the drug, and in the morning following is denied food until the bowels begin to act freely. At about seven o'clock in the morning, thirty grains of thymol in several capsules are administered, followed at intervals of an hour by two similar doses. An hour later (about ten o'clock) a dose of magnesium sulphate is given if the loose stools have not already started. Until free action is had the patient is particularly cautioned against the use of any alcoholic or oil, lest such substances ingested should dissolve the thymol freely and lead to toxic symptoms. In none of the cases observed by the writer was such an accident observed. The stools caused by the thymol and the saline (in several of the above cases the salts were not used, the thymol alone being followed by free evacuation before the time set for the administration of the saline) are thin, watery, generally of a dark-brown color, have the odor of thymol upon them, and show the undissolved drug in larger or smaller particles. The stools are most conveniently washed through a piece of cheese-cloth under a moderately forcible thin jet of water from the tap. A filtration bucket (Fig. 10), with the cheese-cloth fastened about the rim, so as to form a shallow funnel within, has answered the purpose well. When there is much mucus in the stool, preventing free filtration, the previous addition of an alkaline hydrate solution so as to dissolve the mucus has much hastened the operation. The washing is most rapidly done by putting but small portions of feces in the funnel at one time; and the jet of water should be played about the margins of the fecal matter to most rapidly carry the material through the cloth. The solid remnants after washing are transferred to a shallow dish filled with water, in which the parasites sink to the bottom, when they may be readily distinguished and removed to a separate container.

FIG. 10.



Filtration bucket used in washing fecal matter.

LIFE-HISTORY. The life-history of the particular species of hookworm under consideration has not been determined, but there seems no reason to believe it materially different from that of the allied old-world species. The latter is known after emergence from the egg as a rhabditiform embryo, to undergo in its free state at least two moults, experimental observations after alimentary infection of dogs indicating that it subsequently undergoes a third and fourth ecdysis within the host; after which it is fully formed, but requires further growth to attain its adult size. From four to six and from some experiments as much as ten weeks seem requisite for its full development from the time of infection. The ova of *uncinaria americana* under suitable conditions (involving a fair access of oxygen, moisture, and a temperature of about 30° C.) give origin within twenty-four hours similarly to a rhabditiform embryo, measuring 220μ to 250μ (Fig. 9). Stiles (*sup. cit.*) has recognized these after the first and second moult in the free state, after two to three days for the first, and after seven to nine days for the second; and the same author insists upon the need for free access of air to the ova for rapid incubation, indicating that a moist, loose, sandy soil affords the most favorable situation in nature, and that hatching is prevented by actual submersion in water. The writer has made no attempts to follow the development of the parasites, but has found the embryos in numbers in thin fecal material exposed to the air for less than twenty-four hours at ordinary room temperature, suggesting that other conditions than mere submersion may have led to the latter conclusion of Stiles. In an attempt to grow the larvæ in a solid fecal mass at body temperature in a small incubator the eggs failed to incubate, and did not develop in the same substance after removal from the incubator to the general atmosphere of the room within five or six days. At the time it was not thought that the faulty factor was lack of moisture, the failure being attributed at the time to the temperature; but it seems not unreasonable to think that perhaps the real trouble was occasioned by drying (the stool was not, however, at any time dry beyond a putty-like consistence).

After emergence from the egg the embryo lives well in water; and either in unclean drinking water or in infested moist dirt adherent to various articles carried to the mouth, is probably, in a large number of instances, transferred from its free life to the alimentary canal of the host. The habit of "dirt-eating" or "clay-eating" has long been regarded as a probable mode of convection of the larvæ of *uncinaria duodenalis* from their free life in dirty water or in mud to the human host, an idea Stiles has correlated with the American hookworm and the "dirt-eater's anæmia" or "mountain anæmia" frequently met in the "poor white" class of our Southern States. In a large proportion of these dirt-eaters, doubtless, uncinariasis does exist, and, probably, sometimes the habit has occasioned the parasitism by the fact that the dirt eaten by the individual has contained embryo uncinariæ. It should not be lost to mind, however, that dirt-eating is not necessarily mud-eating, and that much of the unclean matter chewed or actually eaten by these people cannot possibly have uncinariæ in it. Frequently the habit is limited to the eating of some particular kind of dirt, as soot taken directly from the chimney, ashes from the hearth, ashes from a tobacco pipe, mortar taken from between bricks in a wall, dry ground, straw or chips; and the true "clay-eater" must be less likely than the real soil-eater or mud-eater to get the worms in his dry or semi-dry clay. Doubtless the habit is often secondary to the anæmia occasioned by the parasite, just as the pica of chlorosis is a symptom rather than causative of the condition. Aside from the actual habit just discussed, it should be kept in mind that mud, possibly carrying the embryo parasites, may be carried to the mouth by the hands in case of individuals engaged in those occupations occasioning frequent soiling of the hands by such material (brickmakers, gardeners, ditchers, and others), or by improperly washed vegetables grown in moist ground (as celery, radishes, cress, etc.). Careful inquiry of the individuals of the above series has failed to indicate any habit of the kind, a habit rather unlikely in persons of their station (but by no means excluded by social status); but all were more or less open to infection by drinking surface water, either from ponds, streams, or surface wells, into which, by drainage, there must, especially in a loose soil, be frequent opportunity for the entrance of ova or embryos. The writer cannot set aside suspicion in connection with cistern water, into which there must often be the chance of entrance of ova, which have been deposited by wind and dust upon the roofs of houses, subsequent rains washing them into the cisterns. Stiles' conclusion as to difficulty of incubation when the ova are submerged is opposed to such an idea; yet the writer would point out that in the bottoms of most cisterns in our Southern sand districts there is to be found an ideal mixture of sand, mud, and charcoal (the last added with a view of purifying the water) in which, aside from the submersion, the ova might well develop.

Recently the view (held as early as 1898 by Loos after a personal experience) of entrance of the embryos through the skin of the host with a probably active penetration to their natural habitat in the intestine has been advanced and fully proved by experimentation upon dogs and human subjects by Loos in connection with the old-world hookworm.[1] Independently, Bentley,[2] having found in the fluid of a vesicle of ground-itch an embryo strongyloid which he identified as *uncinaria duodenalis*, arrived at the idea that "ground-itch" or "water-itch" is the product of invasion of hookworm larvæ into the skin, bearing with them various bacterial infections, the latter determining the type and severity of the dermal attack; in the study of which he produced experimentally conditions of the same character by application of moist soil containing uncinaria embryos to the skin of human beings. Various persons have correlated these ideas, and the view that the ground-itch described by Bentley (foot-itch of coolies, water-itch, panighao, etc.) is a precedent of uncinariasis has met with considerable favor. Whether the eruptive inflammation discussed under the name of ground-itch is of uniform origin and nature is, however, questionable, its reference to other infections than uncinariasis being common. It may be accepted, however, that hookworm larvæ do find access to the human host through the skin, and in their entrance undoubtedly cause more or less irritation, which may, perhaps, lead to an active vesicular and pustular dermatitis as seen in ground-itch, probably varying in aspect and severity from factors other than the parasitic embryos, and not necessarily representing more than one group of the cases known under the name of ground-itch. No experiments, as far as the writer's knowledge extends, have been undertaken in this relation with the larvæ of the American hookworm; but there are reasons for belief that as much may be said in relation to it and the well-known "ground-itch" or "water-itch" of our Southern States, as has been stated in the above-outlined conclusion. The ground-itch of the southern United States is extremely common among those who are accustomed to go barefoot, especially in moist, sandy places; it is especially common among children, usually affecting the feet and ankles, but also seen about the hands and wrists, and is by no means always associated or followed by symptoms referable to uncinariasis. It is, unfortunately, much confused with a number of somewhat similar affections, as the lesions caused about the toes by the penetration of the "chigoe" or "chigger flea" (*pulex penetrans*) and other minute arthropoda. Inquiry of the subjects included in the series of this paper has failed to elicit any history of any such dermal inflammation within the period of the patient's recollection, save in the last case (G.), who, after working for a period with much constancy in his parents' garden, had a severe attack of the affection about the hands and wrists—and this at a time compatible with the supposed time of infection with the hookworm larvæ.

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[1] Centralbl. f. Bakteriol. u. Parasitenk., September, October, 1898; ibid., May, 1901; ibid., February, 1903; Sandwith, Journ. Trop. Med., December 15, 1902.

[2] British Medical Journal, January 25, 1902.

NOTE. The writer, in view of the length of the present article, would leave further consideration of the subject, particularly including the symptomatology of uncinariasis in its American form and the structural changes following the presence of these worms, to a future contribution. This he is especially desirous of doing, although a section of the present paper as submitted for publication was devoted to semeiology, because shortly before reading the proof he met a fatal instance of parasitism by the old-world type of hookworm, which promises to prove interesting in comparison with the disease as found in ordinary American cases of uncinariasis, and which he hopes to be able shortly to present to those interested in the subject.

THE OCCURRENCE OF UNCINARIASIS (ANKYLOSTOMIASIS) IN SOLDIERS OF THE UNITED STATES ARMY.[1]

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FIRST LIEUTENANT AND ASSISTANT SURGEON, UNITED STATES ARMY; PATHOLOGIST AND BACTERIOLOGIST TO THE UNITED STATES ARMY GENERAL HOSPITAL, PRESIDIO OF SAN FRANCISCO, CAL.

The great interest which has attached to the discovery by Stiles that uncinariasis (ankylostomiasis) is a very common disease in the southern portion of the United States, that it is due to a new genus called by him *uncinaria americana*, and the fact that the disease occurs frequently in the Philippine Islands and is being imported into this country in the persons of soldiers of the United States Army returning upon almost every transport, has led me to believe that the cases which have been observed at the Army General Hospital at San Francisco, Cal., during the past eighteen months should be reported somewhat *in extenso*. Since January 1, 1902, there have been twelve cases of infection with *uncinaria* at this hospital. This number includes only those in which the ova were demonstrated in the stools. Several cases besides these have come here with a diagnosis of uncinariasis, but I have been unable to confirm the diagnosis. This small number of cases must not be considered as being an index of the prevalence of the disease in the Philippines. From conversation with several medical officers who have made examinations of the feces in those islands, I am convinced that the disease is very prevalent and forms a considerable portion of the causes of admission to hospitals. Many of the cases occurring in the Philippines are returned to duty, having recovered from the infection, and only the most persistent cases are received here.

Historical. To First Lieutenant Bailey K. Ashford, Assistant Surgeon, United States Army, belongs the credit of having first called the attention of American physicians to the occurrence of this disease in Porto Rico, where he found it very prevalent. Since his publications numerous investigators in this country have reported cases, but it remained for Stiles to prove, by a series of careful and brilliant re-

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[1] Published with permission of the Surgeon-General U. S. A., from the annual report of the bacteriological laboratory of the United States Army General Hospital, Presidio of San Francisco, Cal.